AMO Overview

HPC and Manufacturing

September 21, 2016
Washington DC

Mark Johnson
Director
Advanced Manufacturing Office
www.manufacturing.energy.gov
• Overview of DOE Advanced Manufacturing Office

• Technology Assistance Programs

• Research and Development Consortia

• Research and Development Projects
Clean Energy and Manufacturing: Nexus of Opportunities

Clean Energy Solutions

- Competitiveness in clean energy
- Domestic jobs

Security
- Energy self-reliance
- Stable, diverse energy supply

Economy
- Clean air
- Climate change
- Health

Environment

Goals
- Develop a robust U.S. clean energy economy where products are developed here and manufactured here
- Make the entire U.S. manufacturing sector more competitive by making it more energy productive

3
Advanced Manufacturing and Mission Innovation

- Doubling Clean Energy R&D
- Framework for Clean Energy Targets
- Includes Advanced Technologies for Manufacturing of Clean Energy Products and Efficiency in Manufacturing
Advanced Manufacturing in the Department of Energy

DEPARTMENT OF ENERGY

Office of the Secretary
Dr. Ernest J. Moniz
Secretary
Dr. Elizabeth Sherwood-Randall
Deputy Secretary
Chief of Staff

Energy Efficiency & Renewable Energy
- Sustainable Transportation
- Energy Efficiency
- Renewable Power

Advanced Manufacturing Office

Basic and Applied Science Coordinated Materials & Manufacturing
Climate Action Plan
(EOP / CEQ / OSTP 2014)

Advanced Manufacturing Partnership (AMP2.0)
(NEC / PCAST / OSTP 2014)

Strategic Plans
(DOE 2014 & EERE 2016)

Quadrennial Technology Review
(DOE / Science and Technology 2015)

1) Broadly Applicable Energy Efficiency Technologies for Energy Intensive and Energy Dependent Manufacturing

2) Platform Materials, Process and Information Technologies for Clean Energy Manufacturing with Sustainable Life-Cycle Impact
Some Additional Manufacturing Related Issues

Quadrennial Energy Review (QER): 2015
- Manufacturing for Infrastructure and the Grid

Water-Energy Nexus: 2014
- Water for Energy & Energy for Water

Energy Productivity 2030: 2015
- Double GDP/kJ Economy from Energy

Innovation Strategy: 2015
- Technology, Workforce & Capabilities

Job Training and Apprenticeship: 2015
- Advanced Manufacturing Skills and Opportunities

Revolution Now: 2015
- Cost Effective New Technologies
Energy Intensive Industries

Primary Metals
1608 TBTU

Petroleum Refining
6137 TBTU

Chemicals
4995 TBTU

Wood Pulp & Paper
2109 TBTU

Glass & Cement
716 TBTU

Food Processing
1162 TBTU
Processes for Clean Energy Materials & Technologies
Energy Dependence: Energy Cost Considered in Competitive Manufacturing

Solar PV Cell
Carbon Fibers
Light Emitting Diodes
Electro-Chromic Coatings
Membranes
EV Batteries
Multi-Material Joining
Water Desalination
Deeper Look at Energy in Manufacturing
Current opportunities represent energy savings that could be achieved by deploying the most energy-efficient commercial technologies available worldwide. R&D opportunities represent potential savings that could be attained through successful deployment of applied R&D technologies under development worldwide.
Quadrennial Technology Review: Manufacturing

Technologies for Energy Efficiency & Productivity in Manufacturing

Flow of Material thru Industry (Sustainable Manufacturing)

Combined Heat and Power

Waste Heat Recovery

Advanced Sensors, Controls, Modeling & Platforms

Process Heating

Process Intensification

Roll-to-Roll Processing

Composite Materials

Critical Materials

Direct Energy Conversion Materials (Magnetocaloric, Thermoelectric, etc)

Wide Bandgap Power Electronics

Materials for Harsh Service Conditions

Advanced Materials & their Manufacture

Additive Manufacturing

Enabling Platform Technologies for Clean Energy Products

Training and Workforce Development for Clean Energy Manufacturing

Tools, Partnerships & Best Practices for Energy Efficient and Productivity in Manufacturing

Energy & Resource Management

Advanced Manufacturing Processes

Materials Development
Advanced Manufacturing Topical Areas

**Efficiency Technologies for Manufacturing Processes (Energy, CO₂)**

1. Advanced Sensors, Controls, Modeling and Platforms (HPC, Smart Manufacturing)
2. Advanced Process Intensification
3. Grid Integration of Manufacturing (CHP, DG and DR)
4. Sustainable Manufacturing (Water-Energy, New Fuels & Reused Feedstocks)

**Platform Materials & Technologies for Clean Energy Applications**

5. Advanced Materials Manufacturing
   - (incl: Extreme Mat’l., Conversion Mat’l, etc.)
6. Critical Materials
7. Advanced Composites & Lightweight Materials
8. 3D Printing / Additive Manufacturing
9. 2D Manufacturing / Roll-to-Roll Processes
10. Wide Bandgap Power Electronics
11. Next Generation Electric Machines (NGEM)

Next Step:
Revise AMO Multi-Year Program Plan (MYPP)
With Office Specific Approach in Each Technical Area

QTR Manufacturing (Ch.6) Focus Areas are mapped to Advanced Manufacturing technology topical areas
### Possible Impact Areas of Cross-Cutting Technology for Energy Intensive Industry Sectors

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<tr>
<th></th>
<th>Chemicals &amp; Bio-chemicals</th>
<th>Petroleum Refining</th>
<th>Primary Metals</th>
<th>Forest &amp; Food Products</th>
<th>Clean Water</th>
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<td>SMART Manufacturing</td>
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<td>Process Intensification</td>
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<td>Sustainable Manufacturing</td>
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Many Sector Specific Roadmaps Being Revised through Complementary Program Supported by NIST / AmTech
Bridging the Gap from Discovery to Manufacturing

AMO: Advanced Manufacturing Office

Technology Maturity (TRL; MRL; etc.)

R&D Investment Level

Governments and Universities

Private sector

Gap

R&D Projects

R&D Facilities

Technical Assistance

Concept → Proof of Concept → Lab scale development → Demonstration and scale-up → Product Commercialization
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Technical Assistance: Better Plants

- Key component of President’s Better Buildings Initiative to improve energy efficiency of commercial and industrial buildings by 20% by 2020.
- Voluntary pledge by leading manufacturers and industrial-scale energy users to reduce energy intensity
- DOE provides technical assistance to meet goals

Better Plants Snapshot

<table>
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<th>Partnership Size</th>
<th>Total</th>
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<tbody>
<tr>
<td>Number of Partner Companies</td>
<td>157</td>
</tr>
<tr>
<td>Approximate Number of Facilities</td>
<td>2,400</td>
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<tr>
<td>Percent of U.S. Manufacturing Energy Footprint</td>
<td>11.4%</td>
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Reported Savings through 2014

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<tr>
<td>Cumulative Energy Savings (Tbtu)</td>
<td>457</td>
</tr>
<tr>
<td>Cumulative Cost Savings (Billions)</td>
<td>$2.4</td>
</tr>
<tr>
<td>Cumulative Avoided CO₂ Emissions (Million Metric Tons)</td>
<td>26.6</td>
</tr>
<tr>
<td>Average Annual Energy-Intensity Improvement Rate</td>
<td>2.1%</td>
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</table>

- To date, Better Plants Partners have saved $2.4 billion in cumulative energy costs (more than 0.45 Quads of energy)
Superior Energy Performance™

- SEP is a certification program that helps facilities meet the ISO 50001 energy management standard and verify the savings they achieve
- 28 plants have been certified so far. Nine improved energy performance by an average of 10% and saved over $500,000 per year

ISO 50001 is a foundational tool that any organization can use to manage energy

ISO 50001 Components in place:
- Top Management
- Energy Team
- Policy
- Planning
- Baseline
- Performance Metrics

ISO 50001
Single facility ISO 50001 conformance with verified energy performance improvement
Energy Assessments & Student Training

University-based Industrial Assessment Centers

Support for small/medium sized manufacturing

Energy.gov/IAC
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Shared R&D Facilities & Consortia

Address market disaggregation to rebuild the industrial commons

Then

Ford River Rouge Complex, 1920s

Photo: Library of Congress, Prints & Photographs Division, Detroit Publishing Company Collection, det 4a25915.

Now

- OEM
  - Tier 1
    - Tier 2
      - Tier 3
    - Tier 2
      - Tier 3
  - Tier 1
    - Tier 2
      - Tier 3
    - Tier 2
      - Tier 3

How could we get innovation into manufacturing today?
  - RD&D Consortia based Eco-Systems
  - Public-private partnership to scale
11 Manufacturing Innovation Institutes launched to date

- Over $500 million federal funding catalyzed over $1.2 billion from consortia
- Institutes have attracted hundreds of companies and universities as active partners from across the country
Established regional centers of excellence across a number of fiber composite applications

- 50% Lower Cost
- Using 75% Less Energy
- And reuse or recycle >95% of the material
DOE NNMI Institute #3 – Smart Manufacturing (UCLA/SMLC Lead)

- Advanced sensors and controls for real-time process management

Institute Goals
- >50% improvement in energy productivity
- >50% reduction in installation cost of Smart Manufacturing hardware and software
- 15% Improvement in Energy Efficiency at systems level
- Increase productivity and competitiveness across all manufacturing sectors

Focus on Real-Time
For Energy Management
Modular Chemical Process Intensification

Process Intensification has significant potential to improve costs, increase scalability, improve safety and enhance technology for a variety of energy-intensive, energy-related and clean energy manufacturing applications.

- Applied research and development into the Equipment, Methods and Technologies: Catalysis, Reactions, Separation, Mixing, Hybrid or Integrated Processes, Heating/Cooling, Thermal Recovery, etc.

- Test-bed demonstration of PI in first-of-kind applications

- Develop technologies for manufacturing of process intensified modules.

- Dissemination of knowledge, pre-competitive testing of standards and practices, and education of workforce

- Potential Impact on several key sectors: Chemicals, Refining, Fiber (Pulp/Paper), Fuel Cells, Natural Gas, Environmental Management, Bio-Mass Processing, etc.

Example Possible Application: Gas to Liquids

Proposals in Review
Two upcoming AMO / DOE-led NNMI Institutes

Up to $70 million in Federal cost share for each:

**Modular Chemical Process Intensification:** Focus on breakthrough technologies to dramatically improve energy efficiency of novel chemical manufacturing processes.

Funding Opportunity and Teaming Lists can be found at [https://eere-exchange.energy.gov/](https://eere-exchange.energy.gov/)

**REMADE:** Dramatically reduce life-cycle energy consumption through the development of technologies for reuse, recycling, and remanufacturing of materials.

Funding Opportunity released in June
Critical Materials Institute

A DOE Energy Innovation Hub

- Consortium of 7 companies, 6 universities, and 4 national laboratories
- Led by Ames National Laboratory

Manufacturing Demonstration Facilities

Shared Innovation Space

Supercomputing Capabilities

Scientific Infrastructure

3D Printers in 450 High Schools
1000s of Students

28 WFO
Work for Others

Enabling Workforce Training in Materials, Manufacturing and AM

23 CRADAs
(14 active, 9 in-progress)
Cooperative Research & Development Agreement

23 UFAs
User Facility Agreement

6 MTAs
Material Transfer Agreement

2,952 Visitors
(578 Organizations)

STEM FIRST, 750 Students in MDF

117 NDAs
(105 active, 12 in-progress)
Non-Disclosure Agreement

27 MOUs
Memorandum of Understanding

Supporting Industry Fellows and co-location

America Makes

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy
Printed Cobra Project:
Design to Prototype
Six (6) people in six (6) weeks.  January 2015

- Designed & Printed Car (with Shelby)
- Printer Optimization Design Software (with Dassault)
- Developed Surface Process (with Tru-Design)
- Developed blended polymer / fiber (with Techmer)
- Developed Unique 3D Printing Tool (with Cincinnati)
New MAI technology uses an alternative manufacturing process that could **halve the cost** of traditional vacuum insulation panel (VIP) and simplify their application into building envelopes.

Twice the energy savings of IECC 2012 at half the thickness.

**Rapid Innovation Applied to Building Technologies**

**June 2014**

**First printed go-cart structure**

**Apply the Science**

**Develop the Technology**

**September 2014**

**First printed car, created in collaboration with industry**

**Demonstrate Energy Savings**

**January 2015**

**3D-printed Shelby Cobra**

**Partnership across Offices**

ORNL Demonstrated MAI in Integrated Building, in partnership with Clayton Homes & SOM Partners
Partnerships with Vehicles and Buildings R&D

3D Printing of Large Area Structures

Partnership with Designers, Manufacturers, Universities, Laboratories and Suppliers
MDF: 3D Printing Wind Blade Molds

Bringing Manufacturing Innovation to the Renewable Energy Space

- Enable innovative blade designs
- Achieve lower overall costs and higher efficiencies
- Collaboration with Oak Ridge, Sandia, and TPI Composites
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Ultrafast, femtosecond pulse lasers (right) will eliminate machining defects in fuel injectors. Image courtesy of Raydiance.

Energy-efficient large thin-walled magnesium die casting, for 60% lighter car doors. Graphic image provided by General Motors.

A water-stable protected lithium electrode. Courtesy of PolyPlus

Protective coating materials for high-performance membranes, for pulp and paper industry. Image courtesy of Teledyne

Existing Low Cost Polymeric Membranes

Fouling

Degradation

Crossflow
Filtrate flow
(volume of minor corresponds to flow rate)
Chemical backflush
Coating

Ceramic Solid Electrolyte

Compliant Seal

Li Metal Core
In Support of the Materials Genome Initiative (MGI)

Energy Materials Network
U.S. Department of Energy

Coordinated resource network with a suite of capabilities for advanced materials R&D

MGI - Framework

Data Management & Informatics

Materials Design & Synthesis

Functional Design

Process Scale-Up & Qualification

New Material Innovations for Clean Energy 2X Faster and 2X Cheaper
High Performance Computing for Manufacturing (HPC4Mfg)

• Program teams manufacturers with DOE’s network of National Labs
• Applying High Performance Computing to face critical manufacturing challenges

• Identify New Manufacturing Relevant Technical Challenges to Apply HPC
• High Impact Multiscale Modelling Opportunities
• Connect to Computation Thought Leaders in Labs
• Demonstrate Value in Projects and Share Results
• Opportunity for Lab Talent (esp. Early Career) to Partner with Clean Energy Implementation Community
High Performance Computing for Manufacturing (HPC4Mfg)

- Sponsored by the DOE’s Advanced Manufacturing Office (AMO)
- Teams manufacturers with DOE’s National Labs to apply High Performance Computing to face critical manufacturing challenges
- $3M in funding available in each round
- Applications due every 6 months
- More information at [www.hpc4mfg.org](http://www.hpc4mfg.org)
HPC4Mfg Program: Advancing Innovation

Framework:
• Business-friendly terms and streamlined partnering process
• Leverage decades of investment in platforms, codes, and expertise
• Emphasis on open sharing of successes benefits entire sector

U.S. Manufacturers, Industry Partners, and Consortia
• Identify industry challenge
• Industry partners contribute 20% “in kind” funding
• Share success

National laboratories provide
• HPC capabilities and modeling/simulation expertise
• Assistance to industry to develop full proposal
• Develop standard CRADA sympathetic to protection of industry IP
• DOE funding < $300K
R&D: Next Generation Electric Machines (NGEM)

- Focus on developing energy efficient, high power density, integrated medium voltage drive systems.

Current efforts:
- Manufacturing of high performance thermal and electrical conductors
- Manufacturing of low-loss silicon steel
- High temperature superconducting wire manufacturing
- Manufacturing of other enabling technologies to increase performance.

Potential to save 1.6% of total U.S. electricity consumption each year.
Mission Innovation: Cyclotron Rd and Innovation Accelerators

Embedded Accelerator Model:
Let the nation’s best energy innovators “spin in” to our national labs

1. **Recruit** the world’s best energy technology innovators
2. **Leverage** experts and facilities at a world-class R&D institute
3. **Deploy** people, IP, and technology to the marketplace

...First pilot phase spurred $10 million in follow-on funding and launched 5 privately-funded startups

http://www.cyclotronroad.org/
What does Success Look Like?

Energy Products Invented Here...

...And Competitively made here for 21\textsuperscript{st} Century
Thank You

Questions?